# DIVERSITY AND SPECIES-ABUNDANCE DISTRIBUTION OF BIRDS IN THE TROPICAL FORESTS OF SILENT VALLEY, KERALA[1]

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(*With three text-figures*)

**Key words:** Diversity, species-abundance, Silent Valley, Kerala

Diversity and species-abundance distribution of birds was studied in the evergreen and moist deciduous forests of the Silent Valley, Kerala. The study was carried out from May 1988 to April 1993. Line transects were employed to census the birds. A total of 137 taxa of birds were recorded from the study area. Diversity index of birds in the evergreen forests of Silent Valley and moist deciduous forests of Mukkali was 3.45 and 3.30 respectively (Shannon-Wener Index). Species-abundance models followed truncated log-normal distribution in both the vegetation types, which indicated the absence of a single dominant species, or group, and the presence of a long series of species, with few individuals. Similarity indices showed that the two areas were similar in the composition of bird communities only at 40% level. More species with low numbers of individuals were found in the evergreen forests of Silent Valley than in the moist deciduous forests of Mukkali. Evaluation of the area showed the rich and undisturbed bird community at Silent Valley and Mukkali, which is comparable to tropical forests of other countries. Considering this, it is recommended that this area be added to the existing Silent Valley National Park.

## INTRODUCTION

Avian community studies are effective tools for monitoring a forest ecosystem. Evaluating bird communities of the Western Ghats to plan for biodiversity-friendly development is gaining significance (Pramod *et al.* 1997). The Silent Valley National Park was established in September 1986. It occupies an area of 90 sq. km. The adjacent forest areas, starting from Mukkali to the abandoned dam site, are not included in the National Park; it only has the status of a reserve forest. Considering this, there was a proposal to declare the forests from Mukkali up to Silent Valley National Park as a Wildlife Sanctuary, to function as a buffer zone for the National Park. A study was thus undertaken to determine the diversity and species-abundance distribution of birds in the forests adjacent to the Silent Valley National Park. Ramakrishnan (1983) examined several parameters of the bird communities in the forests of northern Kerala. Diversity and community structure of birds were also studied by Johnsingh *et al.* (1987), Johnsingh *et al.* (1994), Katti (1989), Daniels (1989, 1996, 1997), Gokula and Vijayan (1996), and Sundaramoorthy (1991). Diversity of tropical forest birds has been studied in South America and in many other countries. Similar studies in other regions examined the structure of forest bird communities (Terborgh *et al.* 1990), distribution (Howe *et al.* 1981) and community organisation (Landers and Mac Mahon, 1980).

## STUDY AREA

The study area is located in Palghat district, Kerala State, from 11° 3' to 11° 13' N and 76° 25' to 76° 35' E, in the Western Ghats of southwestern India, comprising the Silent Valley

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and Mukkali Reserve Forest (*JBNHS 97(1)*: 53, Fig. 1.) Two study sites were selected — one was near the abandoned dam site at Silent Valley, with tropical evergreen forests, and the other at Mukkali, with moist deciduous forests. The elevation varies from 500 to 1,500 m above msl and the topography is undulating. Silent Valley and Mukkali fall under the Malabar Rain Forest Realm of Udvardy (1975). According to Rodgers and Panwar (1989), the area falls under the biogeographic zone 5 Western Ghats, and Biogeographic Province 5B Western Ghats mountains, and Biogeographic Subdivision Nilgiri.

There are two distinct seasons in the study area, the monsoon from the end of May to the middle of November, and the dry summer season from December to the first half of May. Compared to Silent Valley (5,096 mm/year), mean annual rainfall was less at Mukkali (4,227 mm/year). Temperature was high at Mukkali, varying from 21 °C in January to 27 °C in April. Pascal (1988) described the vegetation of the Silent Valley as *Cullenia exarillata - Mesua ferrea - Palaquium ellipticum* type, characterised by an abundance of these three species, which may constitute about 80% of the large trees. Degraded areas and other vegetation types, like grasslands, are also found here. Vegetation of the Mukkali area is Southern Secondary Moist Mixed Deciduous Forest (Champion and Seth, 1968).

## Methods

Census methods: Variable width line transects method was adopted for this study (Burnham *et al.* 1981). Whenever a bird was spotted, the species was identified and details like the number of birds and perpendicular distance from the transects were noted (Ali and Ripley 1983a, Ali and Ripley 1983b, Ali 1969). Perpendicular distances were assessed approximately up to metres. To assess the distances, known distances were measured and marked on trees, using a Range Finder, before the census. Two line transects, each 4 km in length, were selected, one at Silent Valley and the other at Mukkali. The first transect covered representative habitats of the area like evergreen forest, small patch of grassland, and fire burned evergreen forest. The second transect covered moist deciduous forest. Along this transect, some rocky patches were also seen, and some areas had a history of fire, 10 years ago.

Census was started 30 minutes after sunrise in all the months. The distance of 4,000 m was covered within a fixed duration of 120 minutes, i.e. 33 m/minute. On rainy days, 150 minutes were spent on completing each transect. No census was done on days with heavy rain and fog. Two samples were collected from each area in a month. Altogether, 150 samples were collected from the study area, between May 1988 and April 1993. Among these, 80 samples were from Silent Valley and 70 from Mukkali, collected over 45 months. There was a gap of 8 months from May 1991 to December 1991 in the collection of data.

**Abundance and density**: The total number of birds seen in each month in two vegetation types was calculated using the census data. Similarly, the density of birds in each area, and individual abundance of selected species, were also calculated.

The Fourier series method was used for analysis, and the density was computed from ungrouped, perpendicular distances from transects. All the assumptions described by Burnham *et al.* (1981) were followed during the census. The density was computed using the software TRANSECT. Ungrouped data was used for analysis. A flock of birds was considered as a single individual, and only one perpendicular distance to the middle of the flock was measured. The actual density was calculated by multiplying density of flocks with the mean flock size. A bird call was considered to be equivalent to a single

individual, and was used, along with sighting records, for density estimation. The total bird density was calculated for each month by pooling the data of all the species. Species richness indices like Margalef index and Menhinick index were calculated for both sites, using the formula described by Magurran (1988). Since the sample sizes from the two areas are not equal, rarefaction using Hurlbert's (1971) formula was done. The standardised sample size (n) is taken as the total number of birds observed at Mukkali (2,628), which is the smaller of the two.

**Species-abundance models**: Species-abundance models were constructed as explained in Magurran (1988). Species of birds were ranked in order of abundance, as represented by individuals seen for each species, and this was plotted in decreasing order for all species against the number of individuals for the two areas. Truncated log-normal distribution was fitted to species-abundance data, using maximum likelihood estimation (Slocomb *et al.* 1977).

**Diversity indices**: Shannon-Wener index, Simpson's index and Hill's diversity numbers N1 and N2 were calculated for Silent Valley and Mukkali, using the program SPECDIVERS.BAS developed by Ludwig and Reynolds (1988). Similarly, evenness was also calculated using the same program. Similarity indices between the two areas were calculated using Jaccard index, Sorenson index and modified Sorenson quantitative (Magurran 1988). In order to find out whether any significant difference existed in the bird diversity between the two places, a 't' test was done using Shannon-Wener index, by the Magurran method (1988). Jack-knifing of diversity index was not attempted, since the two diversities showed significant difference.

## Results

**Abundance and density**: A total of 137 taxa of birds were recorded from the transects. Out of these, 21 species were migrant at Silent Valley and 11 at Mukkali. Silent Valley is not a major wintering area of palaearctic migrants and most of the birds show only local movements. No wintering waterfowl were recorded from the area. The migrants recorded here were wagtails (*Motacilla* sp.), common rosefinch (*Carpodacus erythrinus*) and redwinged crested cuckoo (*Clamator coromandus*). The mean number of birds seen each month over the years is presented in Table 1. The lowest number of birds recorded at Silent Valley was 43 and the highest 153. At Mukkali, it was 41 and 78 respectively. A slight reduction in the total number of birds was seen during the monsoon. Chi-square test was done for both study sites to find out if any significant difference existed in the total number of birds in various months. Results showed significant difference for the Silent Valley ($X^2 = 131.09$; $P = 0.001$; $df = 11$) and Mukkali ($X^2 = 28.69$; $P = 0.01$; $df = 11$).

Mean monthly density of birds in each month over the years is presented in Fig. 1. maximum bird density was found in December and minimum in August, at Silent Valley. At Mukkali, lowest density was found in July and highest in September. Mean density of birds during the study period was 1,122 birds/sq. km,

Table 1
MEAN NUMBER OF BIRDS RECORDED IN EACH MONTH (1988-1993) (N=150)

| | Months | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Area | J | F | M | A | M | J | J | A | S | 0 | N | D |
| Silent Valley | 91 | 87 | 70 | 65 | 76 | 43 | 46 | 47 | 95 | 81 | 109 | 153 |
| Mukkali | 66 | 54 | 77 | 52 | 49 | 66 | 43 | 51 | 68 | 58 | 78 | 41 |

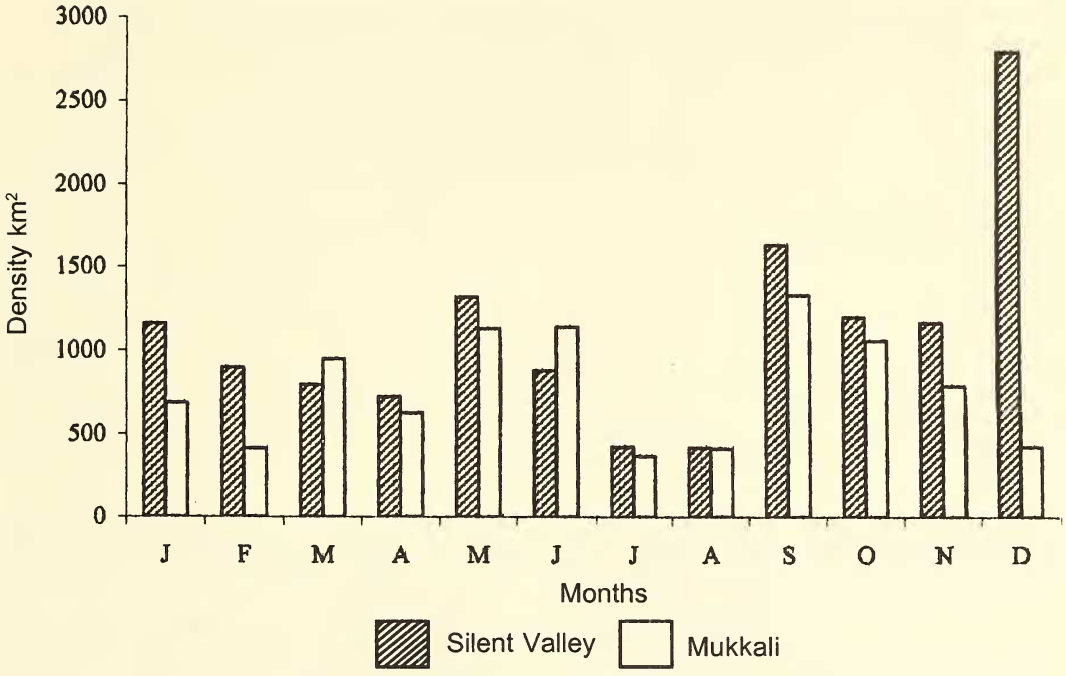


Fig. 1: Density of birds in each month at Silent Valley and Mukkali (1988-1993)

at Silent Valley and 780 birds/sq. km, at Mukkali.

**Individual species abundance**: Out of the 99 and 96 species observed at Silent Valley and Mukkali respectively, the monthly abundance of each of 10 commonly observed species was calculated (Tables 2 and 3). The birds of Silent Valley can be grouped into two, based on the difference in abundance over months. The first group of resident birds showed an almost stable abundance, while the second group registered an increase in abundance in summer. The first group

TABLE 2
MEAN MONTHLY ABUNDANCE OF SELECTED BIRDS AT SILENT VALLEY, 1988-1993 (N=150)

| | Months | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | J | F | M | A | M | J | J | A | S | 0 | N | D |
| Black bulbul | 3 | 5 | 3 | 4 | 1 | - | - | - | 4 | - | 23 | 36 |
| Pied bushchat | 3 | 3 | 4 | 3 | 3 | 2 | 2 | 2 | 2 | 1 | 2 | 6 |
| Goldenbacked woodpecker | 1 | 1 | 2 | 1 | 1 | 0 | 1 | 1 | 1 | 2 | 3 | 1 |
| Grey junglefowl | 3 | 2 | 2 | 1 | - | - | - | 1 | 2 | 2 | 1 | 1 |
| Hill myna | 6 | 8 | 5 | 6 | 5 | 1 | - | - | 14 | 1 | 7 | 8 |
| Malabar whistling thrush | 1 | 1 | 1 | 2 | 3 | 1 | 2 | 1 | 0 | 2 | 1 | 1 |
| Redwhiskered bulbul | 1 | 3 | 4 | 2 | 4 | 0 | 1 | 0 | 3 | 7 | 1 | 1 |
| Small green barbet | 2 | 5 | 4 | 2 | 1 | 0 | 0 | 1 | 2 | 4 | 6 | 6 |
| Southern treepie | 1 | 0 | 1 | 1 | 3 | 1 | 1 | 0 | 0 | 2 | 1 | 2 |
| Yellowbrowed bulbul | 13 | 13 | 9 | 12 | 16 | 19 | 16 | 14 | 18 | 16 | 12 | 12 |

- not recorded

TABLE 3
MEAN MONTHLY ABUNDANCE OF SELECTED BIRDS AT MUKKALI, 1988-1993 (N=150)

| | Months | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | J | F | M | A | M | J | J | A | S | 0 | N | D |
| Black drongo | 2 | 3 | 5 | 1 | 3 | 4 | 4 | - | 3 | 3 | 3 | 4 |
| Blossomheaded parakeet | 4 | 3 | 1 | 1 | - | - | - | - | 1 | 6 | 6 | 3 |
| Goldenbacked woodpecker | 2 | 2 | 1 | 1 | 1 | 2 | 1 | - | 1 | 1 | 1 | - |
| Jungle babbler | 7 | 7 | 11 | 11 | 8 | 13 | 10 | 12 | 13 | 10 | 1 | 4 |
| Magpie-robin | 1 | 2 | 1 | 2 | 1 | 1 | - | - | 2 | - | - | - |
| Racket-tailed drongo | 1 | 1 | 2 | 1 | 2 | 4 | 1 | 2 | 2 | 1 | 2 | 2 |
| Redvented bulbul | 2 | 1 | 4 | 3 | 2 | 2 | 3 | 1 | 3 | 1 | 3 | 2 |
| Small green barbet | 4 | 4 | 6 | 5 | 1 | 2 | 1 | - | 1 | 1 | 3 | 1 |
| Spotted dove | 3 | 2 | 2 | 1 | - | - | 1 | - | 1 | 2 | 1 | - |
| Yellowbrowed bulbul | 2 | 1 | 2 | 1 | - | 2 | 3 | 3 | 1 | 2 | 3 | 2 |

- not recorded

comprised of grey junglefowl (*Gallus sonneratii*), Malabar whistling thrush (*Myiophonus horsfieldii*), southern treepie (*Dendrocitta vagabunda*), yellowbrowed bulbul (*Hypsipetes indicus*), small green barbet (*Megalaima viridis*) and pied bushchat (*Saxicola caprata*).

The second group comprised of black bulbul (*Hypsipetes madagascariensis*), parakeets (*Psittacula* spp.), doves (*Streptopelia* spp.) and pigeons (*Treron* spp.) which showed an increase in number during summer, and a decrease during monsoon, while in June and July they were absent. The small green barbet, roseringed parakeet (*Psittacula krameri*) and the blossomheaded parakeet (*P. cyanocephala*) showed maximum density during the dry months at Mukkali. Compared to the Silent Valley, the overall abundance of birds (Table 3) was lower (in both seasons) at Mukkali and higher during winter. Certain species showed consistent abundance in both areas. The abundance of the yellowbrowed bulbul was stable at Silent Valley, while that of the redvented bulbul (*Pycnonotus cafer*) and small green barbet was stable at Mukkali.

**Species richness indices**: Margalef index and Menhinick index showed higher values for Mukkali (12.18 & 1.89) and lower values for Silent Valley (11.40 & 1.35). Rarefaction showed that the expected number of species at Silent Valley would be 83.

**Species-abundance models**: Another way of describing diversity in a community is through species-abundance or distribution models introduced by Fischer *et al.* (1943). A species-abundance model utilizes all the information gathered in a community, and is the most complete mathematical description of the data (Magurran, 1988). Species-abundance distribution of Silent Valley and Mukkali in semi-log scale is presented in Figs. 2 and 3. This distribution indicates the absence of a single dominant species or group of species, and the presence of a long series of very rare species at Silent Valley and Mukkali. (Species represented by less than 2% of individuals recorded are termed as rare: Magurran, 1988). The observed and expected number of species was compared using $X^2$ goodness of fit test. The test showed no significant difference between the observed and expected distribution. This indicated that the distribution pattern follows truncated log-normal ($X^2 = 8.63$; $P = 0.30$) at Silent Valley. At Mukkali also, the distribution pattern was a truncated log-normal distribution ($X^2 = 9.67$; P 0.16).

**Diversity indices**: Values of four diversity

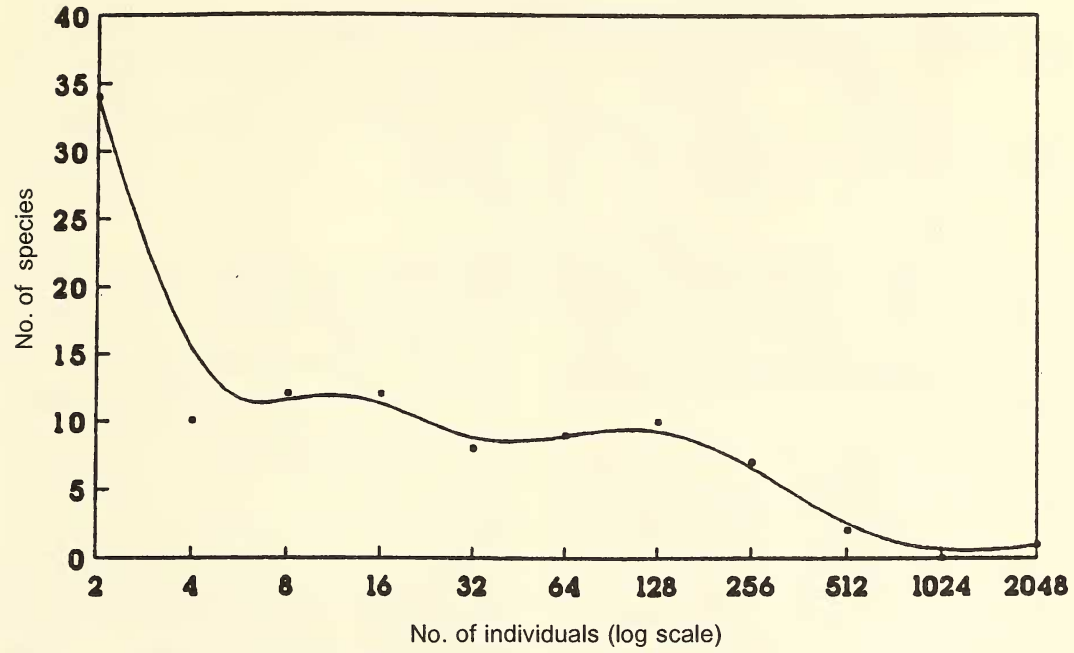


Fig. 2: Species-abundance distribution of birds at Silent Valley

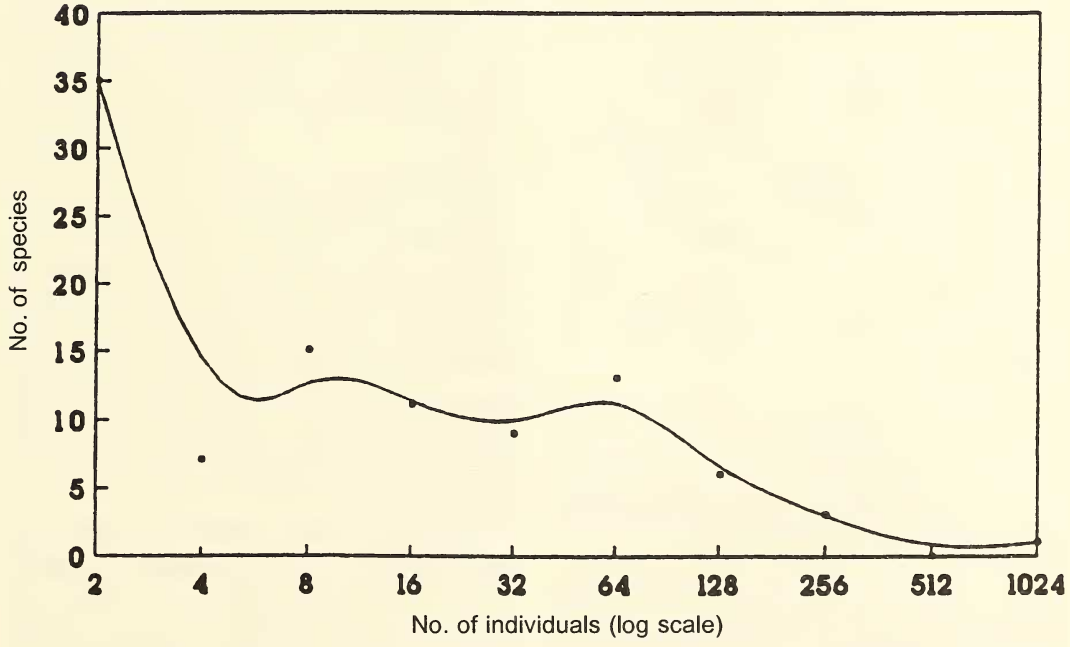


Fig. 3: Species-abundance distribution of birds at Mukkali

TABLE 4
BIRD SPECIES DIVERSITY IN THE STUDY AREA, 1988-93 (N=150)

| | No. of species | No. of individuals | Simpson's Index | Shannon Wener Index | Hill's Number N1 | Hill's Number N2 |
|---|---|---|---|---|---|---|
| Silent Valley | 99 | 5412 | 0.07 | 3.30 | 27.14 | 14.54 |
| Mukkali | 96 | 2641 | 0.06 | 3.45 | 31.38 | 15.67 |

indices obtained for Silent Valley and Mukkali are given in Table 4. A higher diversity index was obtained at Mukkali. Significant difference was obtained in the diversity of the two study sites from the 't' test (t = 4.7734; P = 0.05; df 6,094).

The values of evenness measures showed higher evenness at Mukkali (0.75) than Silent Valley (0.72). Value of Jaccard index (Cj) was 0.40 and Sorenson index (Cs) was 0.57. The computed similarity indices showed medium similarity between the two study sites. Out of the 137 species recorded in the two areas, only 56 species were common to both sites. One disadvantage with the above indices was that they do not consider abundance data. Instead, the presence of abundant and rare individuals is given equal consideration. Similarity measures based on quantitative data solved this problem. Modified Sorenson quantitative was such a measure, and the computed value was Cn = 0.44. Of the three similarity indices computed, Jaccard and Sorenson quantitative shows a similarity above 40% and the Sorenson index shows a similarity of 57% between Silent Valley and Mukkali.

## DISCUSSION

The total number of birds sighted each month showed significant difference between Silent Valley and Mukkali. In December, there was substantial increase in the density and number of birds. Similarly, Morrison *et al.* (1980) also reported reduction of birds during the non-winter period and their increase during winter. One factor influencing the abundance is detectability. Seasonal differences in detectability are common for most of the bird species (Emlen, 1971). These differences result from changes in weather and habitat structure. Increasing foliage density decreased the visibility of birds. But in the study area, foliage abundance was identical in all seasons in the evergreen forests of Silent Valley, and there was a reduction in foliage abundance in the moist deciduous forests of Mukkali during summer (Jayson 1994). Rainfall had some influence on detectability in both the vegetation types. The higher density of birds observed in Silent Valley and lower density in Mukkali indicate the ability of tropical evergreen forest to harbour more birds than moist deciduous forest. The number of individuals per sq. km is comparable to tropical forests of other countries (Table 5). The grey junglefowl, Malabar whistling thrush, southern tree pie and yellowbrowed bulbul showed a stable population, while the black bulbul, doves and pigeons showed an increase in population during summer at Silent Valley. The rest could have moved out due to rainfall and changes in prey abundance. The differences in abundance of these two groups, caused due to local movement, may enable them to cope with the resource availability and climatic conditions. Of these, the black bulbul is a known local migrant.

Species richness in an area is dependent on the availability of food, climate, evolutionary history, and predation pressure. Species richness indices and diversity indices showed high diversity for Mukkali. This is a moist deciduous forest with human interference. It is likely that

TABLE 5
COMPARISON OF PRESENT STUDY WITH SIMILAR STUDIES IN OTHER TROPICAL COUNTRIES

| Country/Area | No. of species | Density | Vegetation | Source |
|---|---|---|---|---|
| Silent Valley (India) | 99 | 1,122 birds/sq. km | Tropical Evergreen | Present study |
| Mukkali (India) | 96 | 780 birds/sq. km | Tropical Moist deciduous | Present study |
| Panama | - | 1,820 birds/sq. km | Tropical Evergreen | Karr (1971) |
| (French) Guiana | 263 | 1,520 birds/sq. km | - | Thiollay (1986) |
| Gabon | 364 | 3,690 birds/sq. km | Rainforest | Brosset (1990) |
| New Guinea | - | 3,450 birds/sq. km | Lowland rain forest | Bell (1983) |
| Amazon | 245 | 1,910 birds/sq. km | - | Terborgh *et al.* (1990) |

the colonisation by man has diversified the food resources available to birds. Another reason, to which the high diversity at Mukkali can be attributed, is the availability of varied microhabitats.

Many rare species of birds occur at Silent Valley and Mukkali, which is typical of tropical forests (Lovejoy, 1975). The factors which control the species richness in an area are broadly divided into historical and ecological (Giller, 1984). Among the historical factors, speciation and crossing of geological barriers, and supply of colonists are more important. Among the ecological factors, mortality due to predation is important, and many such cases were recorded from both the areas.

Currently, many models are available for describing species-abundance distribution and some of them are geometric series: the log-normal, the log series and MacArthur's Broken-stick model. Preston (1948) introduced the log-normal distribution to explain the species-abundance data. Usually in ecological work, distribution of species is always truncated at the left side (Preston 1962). Geometric series patterns are usually found in species-poor or harsh environments. Log-series patterns are usually observed where one or a few factors dominate the ecology of a community. Log-normal distribution is found in most biological populations. The Broken-stick model distribution shows the maximum equitable distribution of available resources. Species-abundance distribution at Silent Valley and Mukkali follows the truncated log-normal model. The Amazonian forest bird community also showed log-normal distribution in species-abundance (Terborgh *et al.* 1990). As in the case of birds, species-abundance of ants in Kobbeduinen and Kooiduinen approximately agreed with log-normal distribution (Boomsa and Van Loon 1982). This clearly explains the existence of an undisturbed bird community in both the areas.

Diversity indices are dependent on two factors, species richness and evenness. Considerable discussion is on about the measurement of diversity, which is directly correlated with the stability of the ecosystems, being higher in biologically controlled systems, and lower in polluted ecosystems (Rosenberg 1976). But some authors like Hurlbert (1971) even consider diversity indices as a 'non-concept'.

Higher diversity indices were obtained for Mukkali than for Silent Valley. As the microhabitats were diverse at Mukkali, they naturally support a more diverse bird community. Similarly, there was slightly higher evenness at Mukkali. This is also natural, as tropical wet evergreen forests support more rare species than other habitats. Similar observations have been reported by Pearson (1977). As the evenness measures show high values, it can be concluded that species are uniformly represented by individuals at Mukkali.

A number of hypotheses have been made to explain the characteristic diversity profiles of different habitats. Habitat heterogeneity, in addition to area, is an important determinant of species richness (Boecklen and Simberloff 1986). Habitat factors such as tree density, basal area, number of tree species, percent ground cover, percent canopy cover and canopy height, are also important in determining diversity. Habitat heterogeneity at Mukkali may be one of the factors causing the higher diversity recorded.

Diversity indices are extensively used in environmental monitoring and testing, and in conservation. As the objective of world conservation strategy is to maximise diversity of habitats, these indices are extensively used to monitor and evaluate habitats. According to Usher (1986), diversity is the most frequently adopted criterion for evaluation of conservation schemes. Diversity indices are directly correlated with the stability of the ecosystem and will be high in biologically controlled systems, as seen at Silent Valley and Mukkali. All diversity indices have limitations because they attempt to combine a number of variables that characterise community structure. The evaluation of the area shows the rich and undisturbed species diversity of birds at Silent Valley and Mukkali, which is comparable to other tropical forests. It is recommended that the forests from Mukkali up to the National Park be declared as a protected area, to function as a buffer zone for the Silent Valley National Park.

ACKNOWLEDGEMENTS

We thank Dr. K.A. Mercey, Dept of Statistics, College of Veterinary and Animal Sciences, Mannuthy, Kerala Agricultural University, for advice in statistical analysis, Dr. Lalitha Vijayan and Dr. Ramakrishnan Palat for valuable suggestions. Financial assistance to the first author from the Ministry of Environment and Forest, Government of India is acknowledged. We thank the anonymous reviewers who helped improve this paper.

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